There are only nine wells located within a 5 km radius of the RMI Sodium Plant, as shown on Figure 4-5. All but one of these wells are located south of the RMI facility and Fields Brook and withdraw water from the Chagrin shale (Personal Communication, Jim Raab, Ohio Department of Natural Resources). The remaining well is approximately 3.8 km northeast of the plant boundary, along Lake Erie. This well is approximately 200 ft deep and yields less 0.1 gpm. It is likely that the water is brackish as this is usually the case in wells over 150 ft deep that are located in the northern portion of the County. Therefore, it is unlikely that the well is used as a source of drinking water (Personal Communication, 1989, Jim Raab, Ohio Department of Natural Resources).

4.2 SITE GEOLOGY AND HYDROGEOLOGY

4.2.1 Site Stratigraphy

Detailed descriptions of the materials encountered at the site are presented on the boring logs found in Appendix 2 of this report. The soil descriptions are based upon visual examination, on site, by an experienced hydrogeologist. The descriptions are in accordance with a soil classification system modified after D. M. Burmister (1958). The geologic strata are graphically depicted on three geologic cross-sections that extend across the site (Figure 4-6). Cross Section A-A' (Figure 4-7) begins at wells 9S and 9D and runs southward in a line extending through wells 8S, 7S and 7D, soil boring SB-11, wells 4S and 4D, and ending at well 1S. Cross-section B-B' (Figure 4-8) begins at wells 9S and 9D and runs southward in a line extending through soil borings SB-16, wells 6S, 5S and 5D, 3S and ending at well 2S. Cross-section C-C' (Figure 4-9) begins at well 2S and runs westward in a line extending through well 1S and ending at well 11D. Cross-sections A-A' and B-B' have a 1:20 vertical exaggeration and cross-section C-C' has a 1:10 vertical exaggeration.

Inspection of the boring logs and cross-sections reveals that approximately 44 to 59 ft of unconsolidated deposits (Ashtabula Till, fill, and/or clay cap) overlie the shale bedrock (Devonian Chagrin Shale) at the plant site. The manmade fill material may be up to 7 ft thick. In addition, 3.5 ft of clay is present in the area which comprises the clay cap over the closed landfill.

4.2.1.1 **Till.** The upper 6 to 13 ft of the glacial till deposits were described as weathered till and fill. An average of 11 ft of weathered till and fill overlies the unweathered till deposits. These deposits were found to be composed of a mottled orange-brown-gray silty clay containing traces of fractured or broken shale fragments, thin silt and fine sand layers, and large oxidized fractures. The oxidized fractures appear to be large vertical and minor horizontal fractures resulting from desiccation cracks (mud cracks) formed by the shrinkage of clay in the course of drying and are typically lined with fine sand. It seems clear that these fractures serve as the primary pathways for the movement of water in the upper weathered zone of the till.

The unweathered till deposits range from approximately 31 to 48 ft in thickness with an average thickness of 40 ft. The unweathered till deposits were found to consist of a gray silty clay containing sand zones and traces of fractured or broken shale fragments which increase in size and frequency with depth. The unweathered till did not contain any fractures or other results of weathering, and therefore, has a very low permeability.

In the borings near the closed landfill (wells 1S, 2S, 4D, and 11D, and borings SB-11, SB-12, and SB-13), a large sandy till zone was encountered at a 17 to 25 ft depth. A more localized sandy zone was noted in well 8S at a depth of 13.5 ft. These sandy deposits are composed of gray fine sand with varying amounts of silt and clay and form gradational contacts with the surrounding till.

4.2.1.2 **Bedrock.** Bedrock consisted of the Chagrin Shale, a gray platey shale, encountered at elevations of 581.4 to 591.5 MSL. A structure contour map has been completed for the top of shale bedrock and is presented as Figure 4-10. As depicted on the contour map, the bedrock surface slopes slightly to the north, toward the Lake Erie basin. This is consistent with the regional slope reported by others.

4.2.2 Groundwater Conditions

4.2.2.1 **Hydraulic Conductivity.** Hydraulic conductivity tests were performed on ten wells, as described in Section 3.6 of this report. These wells are screened in the bedrock or across the weathered/unweathered till interface. The hydraulic conductivity tests were conducted using the "Variable Head Borehole Method" developed by Hvorslev, as described in Cedergren (1977). A summary of the test results is provided in Table 4-1 and the data calculations are contained in Appendix 4.

The hydraulic conductivity values in the wells screened across the weathered and unweathered till are indicative of the weathered till. The difference in hydraulic conductivities could be as much as three orders of magnitude. Therefore because the measured hydraulic conductivities represent weighted averages of the conditions encountered by each well, they more closely reflect that of the higher conductivity weathered till due to its greater contribution to groundwater flow. On the basis of the above described data, typical or average hydraulic conductivity values have been assigned to the upper unweathered till and bedrock water-bearing zones. The hydraulic conductivities in the weathered till ranged from 7.7×10^{-6} cm/sec (well 9S) to 6.8×10^{-5} cm/sec (well 8S) with a geometric mean value of 2.0×10^{-5} cm/sec. The higher conductivity value in well 8S is due to the presence of the localized sandy till zone described in Section 4.2.1.1.

Hydraulic conductivity tests were not conducted in wells screened totally within the unweathered till zone at the Sodium Plant. However, hydraulic conductivity tests have been conducted in monitoring wells screened in the unweathered till zone at the nearby RMI Extrusion Plant (ECKENFELDER INC., 1989) which is located approximately ½ mile from the RMI Sodium Plant. Hydraulic conductivity in wells 306, 307, 314, and 315 (at the RMI Extrusion Plant) ranged from 5.1×10^{-8} to 2.4×10^{-7} cm/sec with a geometric mean of 8.1×10^{-8} cm/sec (see Table 4-1).

TABLE 4-1

HYDRAULIC CONDUCTIVITY TEST RESULTS

Well Number	Geologic Unit	Hydraulic Conductivity (cm/sec)
RMI Sodium Plant		
4S	Weathered Till	1.4×10^{-5}
5S	Weathered Till	3.9×10^{-5}
7S	Weathered Till	1.5×10^{-5}
8S[a]	Weathered Till	6.8×10^{-5}
9S	Weathered Till	7.7×10^{-6}
10S	Weathered Till	1.5×10^{-5}
	Geometric Mean for Weathered Till Wells	2.0×10^{-5}
4D	Shale	1.2×10^{-6}
5D	Shale	2.5×10^{-6}
9D	Shale	5.6×10^{-8}
11D	Shale	7.0×10^{-8}
	Geometric Mean For Shale Wells	1.7×10^{-6} (4D, 5D) 6.2×10^{-8} (9D, 11D)
RMI Extrusion Plant[b]		
306	Unweathered Till	5.1×10^{-8}
307	Unweathered Till	5.8×10^{-8}
314	Unweathered Till	2.4×10^{-7}
315	Unweathered Till	6.2×10^{-8}
	Geometric Mean for Unweathered Till Wells	8.1×10^{-8} cm/sec

[a]Well 8S is partially screened in the sandy till zone (see Figure 4-7).
[b]ECKENFELDER INC., 1989. "Supplemental Hydrogeologic Assessment, RMI Extrusion Plant, Ashtabula, Ohio".

The bedrock hydraulic conductivities in the southeast portion of the site (wells 4D and 5D) had a geometric mean value of 1.7×10^{-6} cm/sec, while the bedrock hydraulic conductivities in the remainder of the site (wells 9D and 11D) had a geometric mean value of 6.2×10^{-8} cm/sec. Although not tested, it is assumed well 7D would have hydraulic conductivity values in the 10^{-8} cm/sec range due to extremely slow recovery during sampling.

4.2.2.2 Groundwater Occurrence and Flow. Groundwater has been observed to occur within two zones beneath the RMI site:

- An unconfined water table zone within the fill and upper weathered glacial till with moderate hydraulic conductivity and within the deeper unweathered glacial till with presumed lower hydraulic conductivity.

- A confined water-bearing zone within the low hydraulic conductivity shale.

Monitoring wells have been installed in each of these zones, allowing the determination of their respective water table and piezometric surfaces. In addition, piezometers were installed in the glacial till and staff gauges were installed to further define the water table surface. Water level data are provided in Tables 4-2, 4-3, and 4-4.

The unconfined water table zone in the glacial till receives recharge predominantly through direct infiltration of precipitation. Therefore, its water table surface is likely to be more sensitive to seasonal variations than the deeper shale zone. The surface of the glacial till water table zone occurs at a shallow depth, ranging from ground surface at well 1S to approximately 7 ft at well 10S. Well 2S is the exception with a water table elevation approximately 1.5 ft above ground surface. This is most likely due to the dense non-aqueous phase liquid (DNAPL) present in the well which is further discussed in Section 6.6.

TABLE 4-2

MONITORING WELL
WATER LEVEL DATA

Well Number	Depth	Geologic Unit	Elevation		Groundwater Elevation		Depth to Water Table Below Ground Surface	
			Reference (ft MSL)	Ground (ft MSL)	17-Nov-88 (ft MSL)	10-Jan-89 (ft MSL)	17-Nov-88 (ft)	10-Jan-89 (ft)
1S	25.0	Till	638.78	636.0	634.78	636.38	1.22	-0.38
2S	25.0	Till	638.64	636.3	637.34	637.14	-1.04	-0.84
3S	15.0	Till	642.20	639.6	638.65	637.36	0.95	2.24
4S	15.0	Till	639.99	637.2	634.14	634.11	3.06	3.09
4D	64.4	Shale	639.59	637.4	631.24	631.59	6.19	5.81
5S	15.0	Till	645.67	642.9	636.07	637.42	6.83	5.48
5D	75.7	Shale	645.17	642.9	635.47	637.23	7.43	5.67
6S	15.5	Till	647.95	645.1	637.35	637.70	7.75	7.40
7S	15.0	Till	643.61	641.2	639.66	639.67	1.54	1.53
7D	76.7	Shale	642.41	641.3	Dry	567.91	Dry	73.39
8S	15.0	Till	643.50	640.7	637.50	637.85	3.20	2.85
9S	15.0	Till	640.82	638.1	637.82	637.47	0.28	0.63
9D	77.0	Shale	640.29	638.4	567.94	574.55	70.46	63.85
10S	15.0	Till	644.57	641.8	636.02	635.95	5.78	5.85
11D	65.5	Shale	639.23	636.7	588.18	614.18	48.52	22.52

TABLE 4-3

PIEZOMETER WATER LEVEL DATA

Piezometer Number	Top of Casing Elevation	Groundwater Elevation	
		25-Sep-88	10-Jan-89
PZ-1	641.57	635.66	638.57
PZ-2	636.39	628.94	632.50
PZ-3	641.50	631.60	631.56
PZ-4	643.40	639.28	639.85
PZ-5	643.45	636.49	638.27
PZ-6	641.95	637.90	638.82
PZ-7	638.65	628.75	635.15
PZ-8	638.02	635.24	636.02
PZ-9	645.63	636.20	636.03
PZ-10	644.00	638.18	638.13
PZ-11	646.20	638.52	638.02
PZ-12	647.13	639.06	642.57
PZ-13	646.65	638.76	637.36
PZ-14	643.96	638.72	638.70
PZ-15	645.61	636.42	639.63
PZ-16	640.27	634.70	638.22
PZ-17	641.01	635.81	638.59
PZ-18	636.78	634.72	634.93
PZ-19	643.54	636.48	638.14
PZ-20	640.58	633.37	636.11

TABLE 4-4

STAFF GAUGE
WATER LEVEL DATA

Staff Gauge Number	Elevation	Surface Water Elevation	
		25-Sep-88	10-Jan-89
SG-1	634.81	629.10	629.40
SG-2	632.25	630.89	630.28
SG-3	634.66	632.13	632.26
SG-4	634.74	633.38	633.43
SG-5	635.71	633.44	633.55
SG-6	639.52	634.05	634.07
SG-7	636.15	634.99	635.00
SG-8	643.85	643.17	642.99
SG-9	643.58	643.25	643.36
SG-10	643.40	642.56	642.78
SG-11	645.55	NA[a]	643.49
SG-12	645.97	643.67	639.97
SG-13	645.58	NA	642.78
SG-14	640.30	640.76	639.70
SG-15	640.72	639.77	638.62
SG-16	641.06	638.95	639.63

[a]NA = Not measured.

The direction of groundwater flow in the glacial till is assumed to be perpendicular to the groundwater contours, as indicated on the groundwater contour map (Figure 4-11). Groundwater flow direction within the till is variable due to the recharge effects to the water table by the seven clay lined ponds in the north, east, and southeast areas of the site. The two brine ponds in the southwest corner of the site are synthetically lined and, therefore, have a minimal effect on groundwater. In general, the groundwater is mounded around the clay lined ponds and the overall groundwater flow directions radiate outward from the site. At least a portion of the groundwater appears to discharge to the DS tributary of Fields Brook in the vicinity of the closed landfill and to the drainage ditch east of the five ponds. The drainage ditches are very shallow and may not intercept the entire portion of the water table zone. However, the flow lines for shallow groundwater as shown in Figure 4-11 indicate that the surface drainage area to the south and west of the closed landfill acts somewhat as a groundwater divide. Therefore, it is assumed that the DS tributary and the drainage ditch to the east restrict groundwater from flowing past that point. Because no piezometers or wells are installed on the south side of the DS tributary or on the east side of the drainage ditch, groundwater flow in these areas cannot be completely evaluated. All other surface water drainage appears to occur only during storm events.

Based upon the low permeability and considerable thickness of the unweathered glacial till and the relatively high piezometric surface in the bedrock, it is apparent that only a minimal downward vertical gradient exists between the two water bearing zones.

The rate of horizontal groundwater flow within the water table zone can be estimated through the use of Equation 4.1:

$$V_s = \frac{Ki}{N_e} \tag{4.1}$$

where:

V_s = seepage velocity (cm/sec)

K = hydraulic conductivity (cm/sec)

i = hydraulic gradient (dimensionless)

N_e = effective porosity (dimensionless)

The mean hydraulic conductivity in the till has previously been estimated to be 2.0×10^{-5} cm/sec. The hydraulic gradient has been determined to range from 0.01 to as high as 0.10 near the ponds. A typical value of the effective porosity can be assumed to be 0.3 (Freeze and Cherry, 1979). Inserting the above data into the equation yields horizontal flow rates of approximately 0.7 ft per year throughout most of the RMI site and 7.0 ft per year adjacent to the ponds.

Through the use of the above described data, it is possible to determine the volume of groundwater discharge, on site, to the DS tributary of Fields Brook; and, off site, east to the drainage ditch. This discharge rate is calculated using Darcy's Law (Equation 4.2):

$$Q = kiA \qquad (4.2)$$

where:

Q = discharge rate (cu ft/sec)

k = hydraulic conductivity (ft/sec)

i = hydraulic gradient (dimensionless)

A = cross-sectional area through which flow is assumed to occur (sq ft)

It is assumed that discharge will occur throughout the thickness of the unweathered till and manmade fill into the drainage ditches. The average thickness of fill and unweathered till at the site is 11 ft. For the purpose of this calculation, discharge to a one linear foot section of the ditch will be considered, resulting in an area of 11 sq ft.

The mean observed hydraulic conductivity in the glacial till water-bearing zone is 2.0×10^{-5} cm/sec converted to 6.6×10^{-7} ft/sec. The horizontal hydraulic gradient has been calculated to be 0.01 throughout most of the site and adjacent to the DS tributary, and 0.10 near the ponds discharging east off site to the drainage ditch. This results in calculated discharge rates of 8.5×10^{-8} ft^3/sec or 0.05 gal/day per linear foot to the DS tributary and 8.5×10^{-7} ft^3/sec or 0.5 gal/day per linear foot east to the drainage ditch.

Groundwater occurs under fully confined conditions in the deeper shale bedrock water-bearing zone. The piezometric surface within this zone has been partially defined through the use of water level measurements from monitoring wells screened within the shale. The piezometric surface appears to be at or near the water table surface throughout the site, although only water levels in wells 4D and 5D substantiate this. Extremely low hydraulic conductivities have been measured in wells 9D and 11D (geometric mean 6.2×10^{-8} cm/sec) and is presumed to be low in well 7D. It is apparent that the true piezometric surface in these wells has not yet been established, but should with time. The water levels in the these wells are much lower than wells 4D and 5D but have increased steadily from November 1988 to January 1989 (at least 4 ft in 7D, 7 ft in 9D, and 26 ft in 11D) while the shallow water levels remained approximately the same. Because water levels had not fully recovered in several bedrock wells, it is recommended that water level measurements be collected after all wells have stabilized to better assess the piezometric surface of the bedrock groundwater.

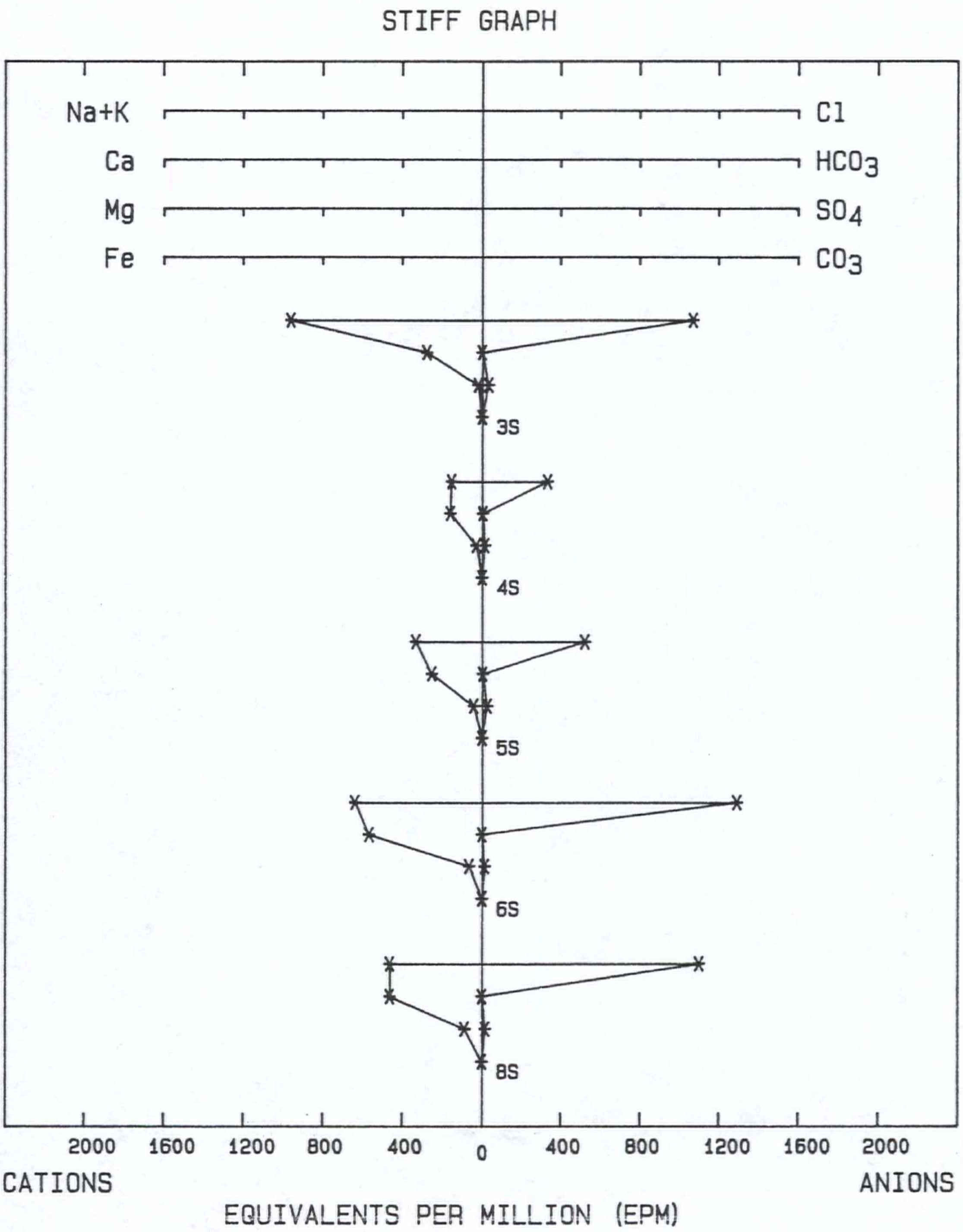
Based upon the limited piezometric surface data, it is assumed that horizontal flow of groundwater in the shale is toward the north and Lake Erie. The rate of horizontal flow through the bedrock can be estimated on the basis of the previously mentioned equation. Utilizing average hydraulic conductivities of 1.7×10^{-6} cm/sec (wells 4D and 5D) and 6.2×10^{-8} cm/sec (wells 9D and 11D), an average hydraulic gradient of 0.01 and a porosity of 0.1, flow velocities are calculated to be 0.006 to 0.18 ft per year (Equation 4.1).

4.2.3 Site Geochemistry

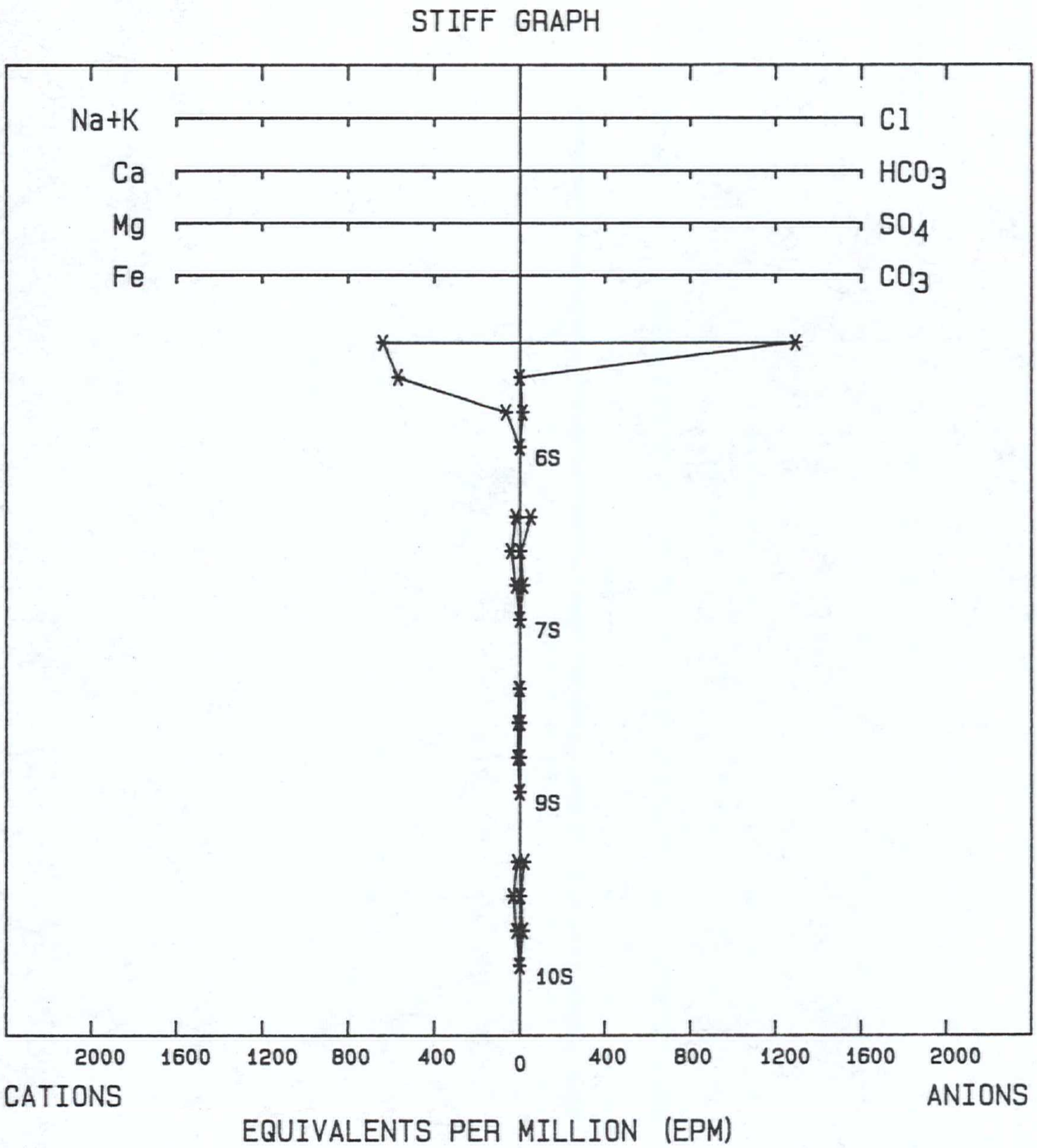
To allow for a more complete understanding of the hydrogeologic and geochemical regime in the till and underlying shale at the RMI site, geochemical evaluations of major ion data were conducted, utilizing both Stiff diagrams and Piper trilinear plots (Hill, 1942; Piper, 1944). All major ion data are found in Appendix 4.

The data have been analyzed using computer software marketed by Hall Ground-Water Consultants, Inc. of St. Albert, Alberta, Canada, under the name "Ground-Water Chemistry Programs, Version 7.0". The software calculates the ionic balances and generates Piper trilinear, Stiff, and pie diagrams. These diagrams are particularly useful for assessing the similarities and differences in water quality between wells and between water-bearing zones. The Stiff diagram often possesses a distinctive shape that is characteristic of the water in a given water-bearing zone or a portion thereof. Figures 4-12, 4-13, and 4-14 are Stiff diagram patterns for samples collected January 1989.

The Piper trilinear diagram permits the plotting of all of the analyses on a single diagram. In constructing a Piper trilinear diagram, the relative percentages of cations (calcium, magnesium, and sodium plus potassium) are plotted on the lower left cation triangle, while the relative percentages of anions (chloride, sulfate, and carbonate plus bicarbonate) are plotted on the anion triangle, located on the lower right side of the diagram. A central plotting position is then established for each point in the central plotting rhomb by projecting the intersection of rays of the plotting positions from the cation and anion triangles. Water from distinct water-bearing zones will typically plot within separate, reasonably well-defined fields on the central "diamond" in the trilinear diagram. This technique provides the ability to distinguish between groundwaters which originate from geochemically distinct water-bearing zones and to identify groundwater which may represent a mixture of differing groundwater types.



PROJECT: RMI SODIUM FILE: 6120 LOCATION: ASHTABULA OHIO	**STIFF GRAPHS** **WELLS 3S,4S,5S,6S,8S**
ECKENFELDER INC. Nashville, Tennessee Mahwah, New Jersey	FIGURE: 4-12

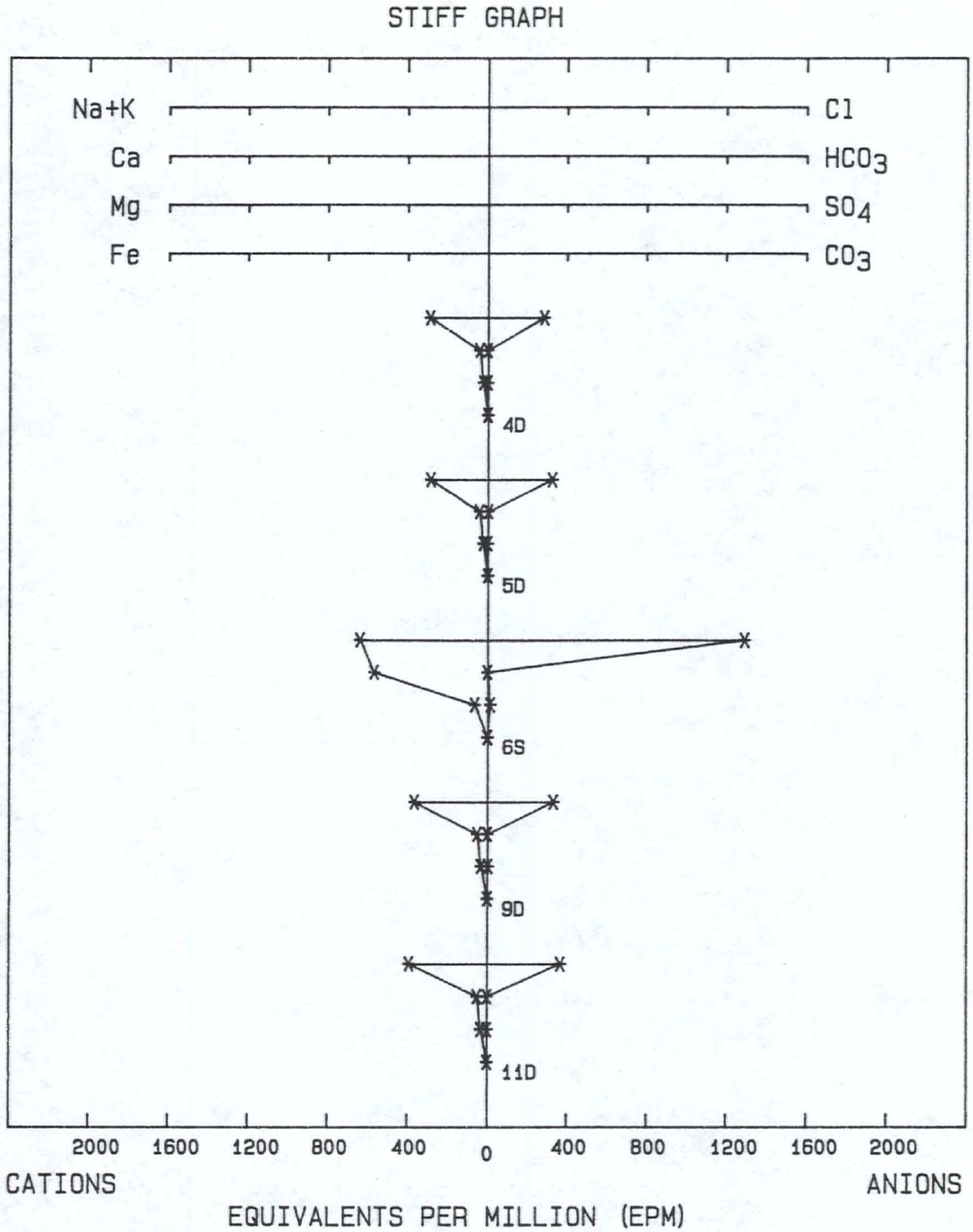


PROJECT: RMI SODIUM
FILE: 6120
LOCATION: ASHTABULA OHIO

STIFF GRAPHS
WELLS 7S,9S,10S

ECKENFELDER INC.
Nashville, Tennessee
Mahwah, New Jersey

FIGURE: 4-13



PROJECT: RMI SODIUM
FILE: 6120
LOCATION: ASHTABULA OHIO

STIFF GRAPHS
WELLS 4D,5D,9D,11D

ECKENFELDER INC. Nashville, Tennessee
Mahwah, New Jersey

FIGURE: 4-14

Data from all groundwater samples analyzed for major ions at the RMI Sodium plant were plotted on a single trilinear diagram (Figure 4-15). Because of high levels of organics present, wells 1S and 2S were not analyzed for major ions as discussed in Section 3.7. As could be expected with the large number of wells, there is a significant overlap of the data points, rendering its difficult to read the computer-generated sample point identification for all samples. However, the large number of data points illustrates very well the differences in groundwater chemistry between the distinct water-bearing zones. This is schematically illustrated on Figures 4-16 and 4-17.

The groundwater can be divided into three distinct groupings:

- Shallow glacial till groundwater associated with the ponds and fill areas (wells 3S, 4S, 5S, 6S, and 8S).

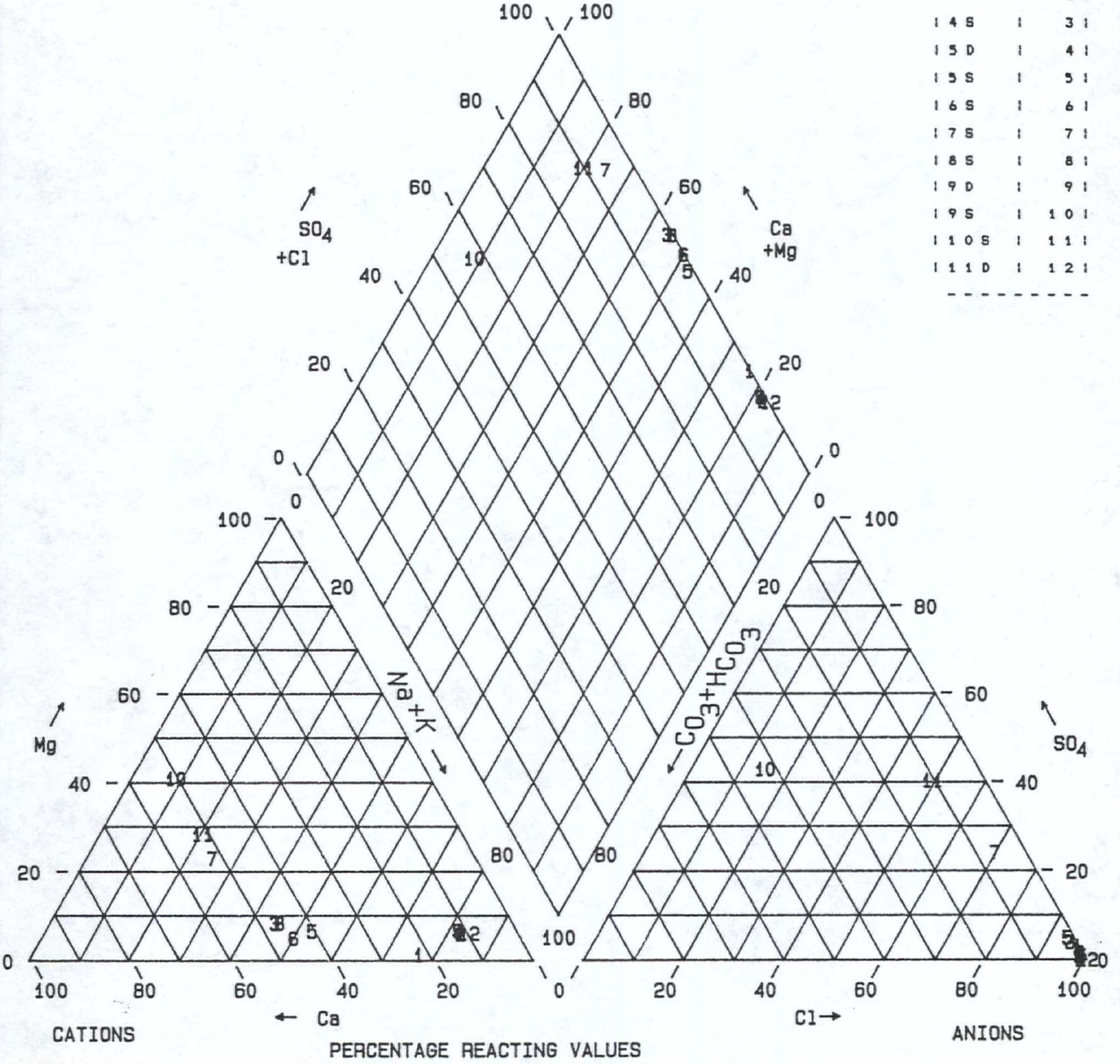
- Shallow glacial till groundwater in background areas (wells 7S, 9S, and 10S).

- Deep shale groundwater (wells 4D, 5D, 9D, and 11D).

The major ion data for wells screened in the glacial till water-bearing zone associated with the ponds and fill areas, indicate that sodium and calcium are the dominant cations and chloride is the dominant anion. The major ion data for the till water-bearing zone in background areas indicate that calcium is the dominant cation and chloride is the dominant anion. Sodium and magnesium are the subordinate cations and bicarbonate and sulfate are the subordinate anions. The major ion data for the shale water-bearing zone indicate that sodium is the dominant cation and chloride is the dominant anion.

In addition, a geochemical evaluation of major ion data was conducted for waters in the ponds, french drains, and drainage ditches (Figure 4-18). There was significant overlap of data points on the Piper trilinear diagram for surface water rendering it very difficult to distinguish between different surface waters. Although this was the case, it is apparent that surface water

WELL NO.	DIA NO.
3S	1
4D	2
4S	3
5D	4
5S	5
6S	6
7S	7
8S	8
9D	9
9S	10
10S	11
11D	12



PROJECT: RMI SODIUM
FILE: 6120
LOCATION: ASHTABULA OHIO

PIPER TRILINEAR DIAGRAM

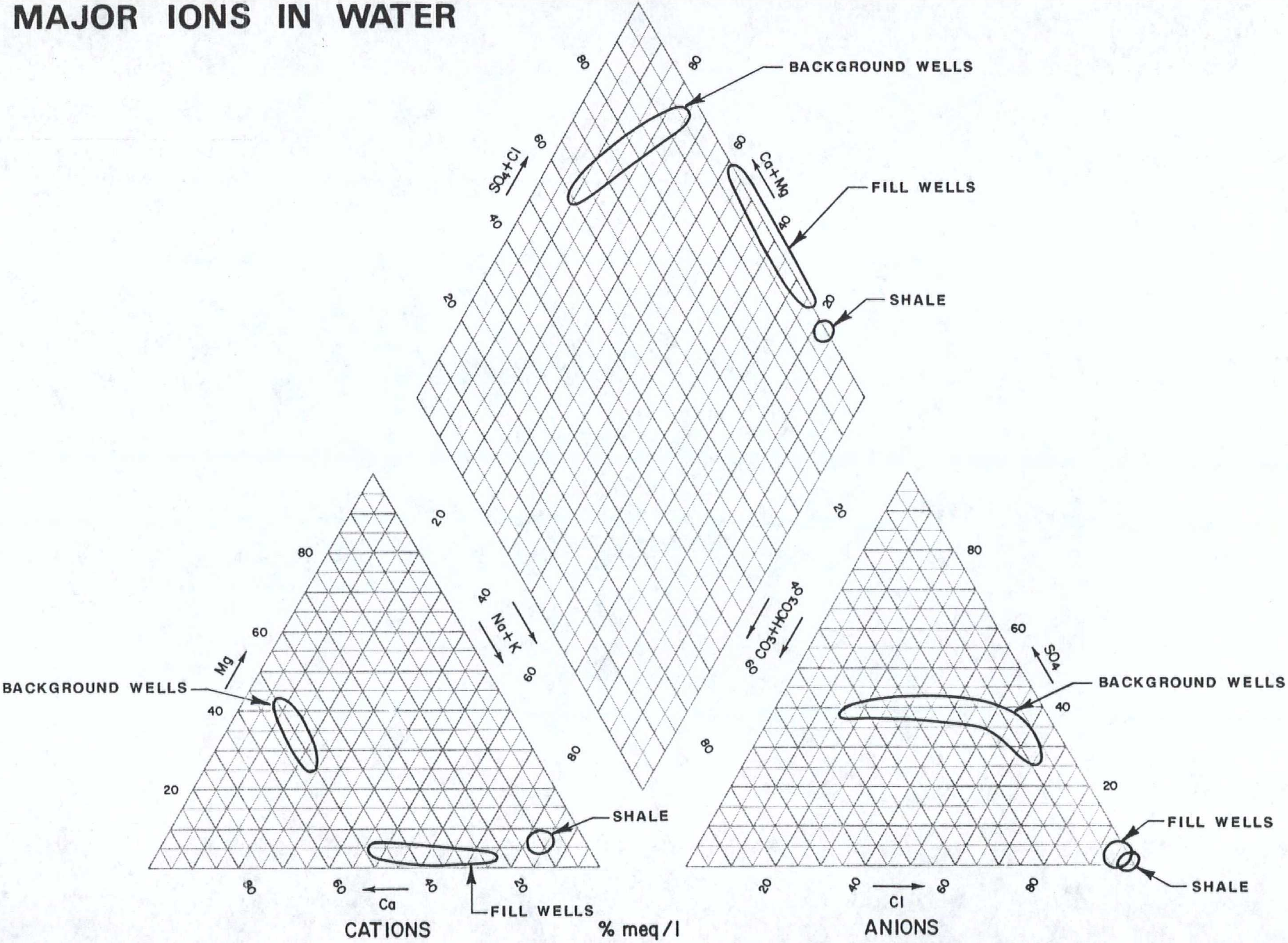
ECKENFELDER INC.
Nashville, Tennessee
Mahwah, New Jersey

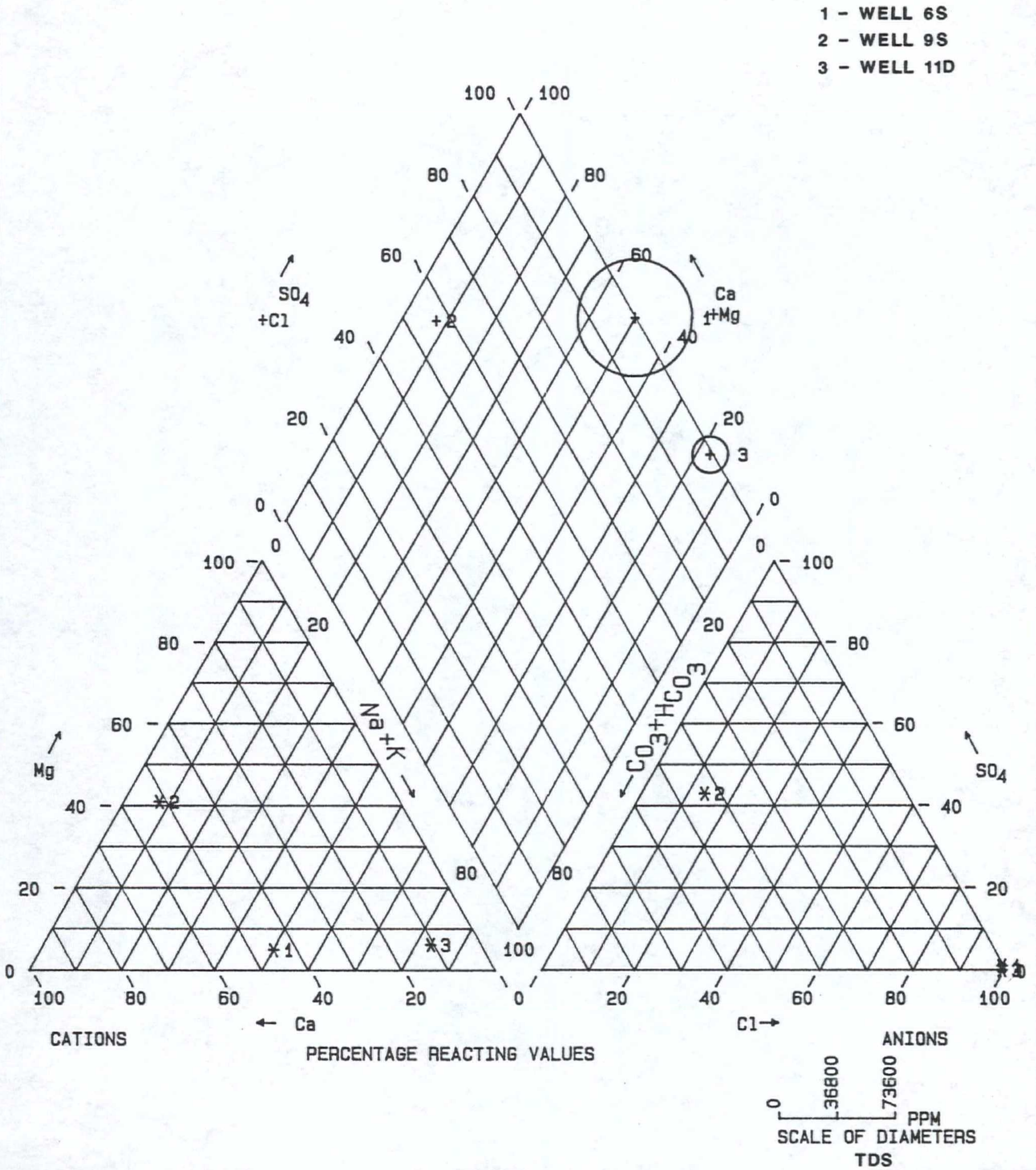
FIGURE: 4-15

FIGURE 4-16

GENERAL TRILINEAR PLOT

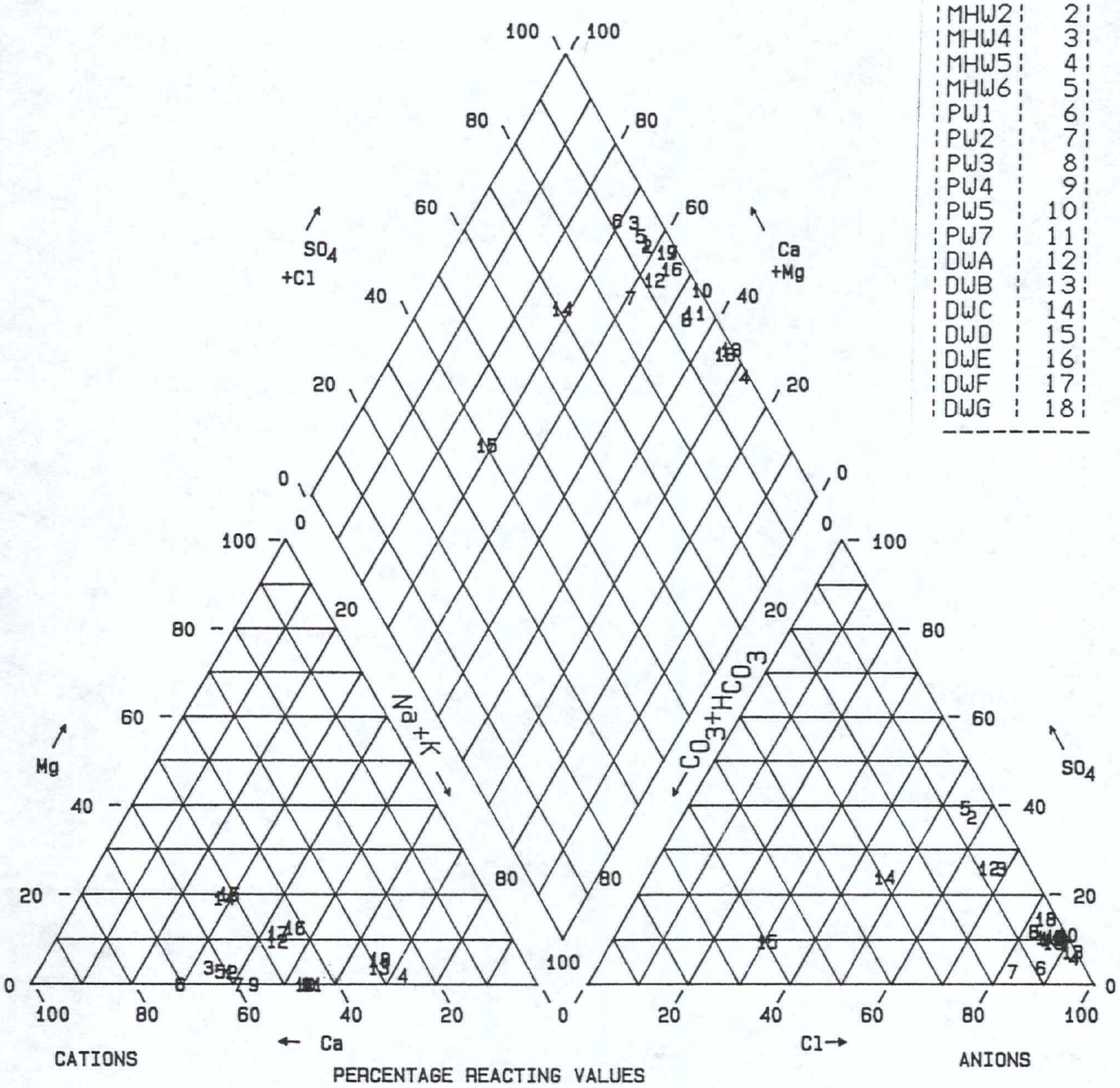
MAJOR IONS IN WATER





PROJECT: RMI SODIUM FILE: 6120 LOCATION: ASHTABULA OHIO	PIPER TRILINEAR DIAGRAM
ECKENFELDER INC. Nashville, Tennessee Mahwah, New Jersey	FIGURE 4-17

WELL NO.	DIA NO.
MHW1	1
MHW2	2
MHW4	3
MHW5	4
MHW6	5
PW1	6
PW2	7
PW3	8
PW4	9
PW5	10
PW7	11
DWA	12
DWB	13
DWC	14
DWD	15
DWE	16
DWF	17
DWG	18



PROJECT: RMI SODIUM
FILE: 6120
LOCATION: ASHTABULA OHIO

PIPER TRILINEAR DIAGRAM

ECKENFELDER INC.
Nashville, Tennessee
Mahwah, New Jersey

FIGURE 4-18

major ions are very similar to shallow glacial till groundwater associated with the ponds and fill areas. For example, the major ion data for the two wells nearest the ponds (wells 5S and 6S) are very similar to the major ion data for the pond water and french drain manhole water. The major ion data for the background drainage ditch surface water sample DW-D are very similar to the major ion data for the groundwater in the background wells. These data confirm the flow directions in the till water table contour map.

4.2.4 Groundwater Classification

The USEPA issued its Groundwater Protection Strategy in August 1984. The core of the strategy is a differential protection policy that recognizes that different groundwaters require different levels of protection. A three-tiered classification system was established as the vehicle to implement this strategy (USEPA, December 1986a):

- Class I: Special groundwater (irreplaceable sources of drinking water and/or ecologically vital).

- Class II: Groundwater currently a source of drinking water (Subclass IIA) or potentially a source of drinking water (Subclass IIB).

- Class III: Groundwater not a source of drinking water due to insufficient yield, high salinity, or contamination that cannot be reasonably treated. Subclass IIIA groundwaters exhibit an intermediate to high degree of interconnection to adjacent groundwater units or surface waters or have insufficient yield. Subclass IIIB groundwaters exhibit a low degree of interconnection to adjacent groundwater units or surface waters.

Based on the final draft of "Guidelines for Ground-Water Classification under the EPA Ground-Water Protection Strategy" issued by the USEPA in December 1986 (USEPA, 1986a), it is proposed that the uppermost water-bearing zone (or that in the glacial till deposits) in the vicinity of the RMI Sodium Plant be classified as Class IIIA groundwater on the basis of insufficient yield. The steps taken to arrive at this classification are described below. The steps are summarized in the procedural classification flow chart shown in Figure 4-19.

4.2.4.1 Subdivision of Classification Review Area. The first step in the classification process was to delineate a Classification Review Area (CRA). A two-mile radius is typically used to delineate the CRA according to USEPA guidelines (USEPA, 1986a). A two-mile radius around the RMI Sodium Plant boundaries delineates the CRA and is shown in Figure 4-20.

According to USEPA guidelines (USEPA, 1986a), groundwater units are delineated on the basis of three types of boundaries: 1) permanent groundwater divides, 2) thick, laterally extensive, low permeability geologic units, and 3) permanent fresh water-saline water contacts. Water within a groundwater unit is inferred to be highly interconnected, and therefore, a common use, value, and protection strategy can be determined. In addition, boundaries separating waters of different classes must coincide with boundaries of groundwater units.

The CRA for the RMI Sodium Plant was subdivided into two groundwater units on the basis of the "Type 3" boundary (fresh water-saline water contact): the uppermost water-bearing zone in the unconsolidated glacial till deposits and the underlying bedrock water-bearing zone in the Chagrin Shale. Although a sandy till zone has been identified in the unconsolidated till deposits underlying the Sodium Plant facility, this zone forms gradational contacts and is likely to be highly interconnected with the surrounding till. None of the boundaries discussed above are present to separate the sandy till zone from surrounding unconsolidated till deposits and, therefore, the sandy till zone cannot be subdivided into a separate groundwater unit.

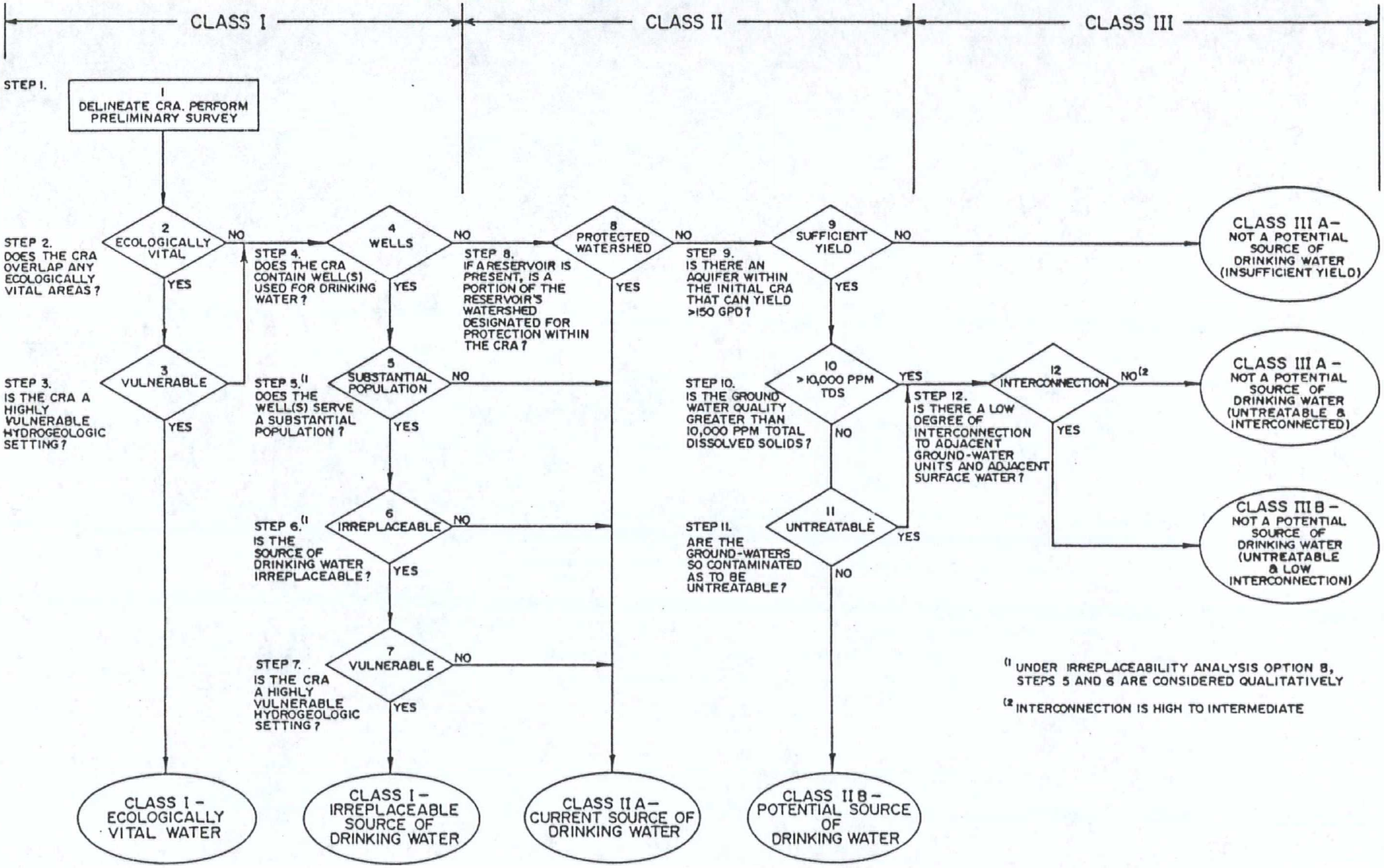


FIGURE 4-19 USEPA PROCEDURAL CLASSIFICATION CHART FOR GROUNDWATERS

As discussed in Section 4.1, the RMI site and surrounding area is underlain by the Ashtabula Till. Beneath the till is the Devonian Chagrin shale which may be up to 1,200 ft thick in Ashtabula County. It in turn is underlain by Devonian limestone and the Silurian Salina Formation which is composed of carbonates, shale, and evaporates. Because of the great thickness and low hydraulic conductivity of the Chagrin shale, it is unlikely that any aquifer below the shale would be affected by activities at the RMI facility. The amount of any open fractures present in the shale would likely decrease with depth because of increasing pressure exerted on the bedrock as depth increases.

The presence of brackish water in the Chagrin shale is well documented. Salt water may be encountered as shallow as 50 ft into the shale (Hartzell, 1978). In fact, analytical data for samples collected in monitoring wells screened from 8 to 25 ft into the shale at both the RMI Sodium and RMI Extrusion plants (ECKENFELDER INC., 1989) show total dissolved solids (TDS) levels in excess of 10,000 mg/l (see Table 4-5). Well logs for the few wells that are located in the CRA (all of which withdraw water from the Chagrin shale) often note that the water encountered is salty (Personal Communication, 1989, Jim Raab, Ohio Department of Natural Resources).

As discussed in Section 4.2.3, major ion data indicate that the chemical make-up of the water within the Chagrin shale is distinct from the shallow water bearing zone. Also, TDS levels in the bedrock water-bearing zone are much higher than background levels in the shallow water-bearing zone. It is highly unlikely that the high TDS levels found in the bedrock water-bearing zone are due to activities at the RMI Sodium Plant. As further discussed in Section 6.1.2, the bedrock water-bearing zone is not believed to be affected by activities at the RMI Sodium Plant.

TABLE 4-5

TDS CONCENTRATIONS IN MONITORING WELLS
SCREENED IN THE SHALE BEDROCK

Well No.	TDS Concentration (mg/l)	Depth of Screen Below Bedrock (ft)
RMI Sodium Plant Wells		
4D	17,100-17,300[a]	8-18
5D	16,600-17,700[a]	9-19
9D	16,100-21,000[a]	8-18
11D	15,900-23,900[a]	
RMI Extrusion Plant Wells[c]		
402	23,000[b]	20-25
404	10,300[b]	20-25

[a]Data results from sample dates 11/21/88 and 01/16/89.

[b]Data results from sample date 01/16/89.

[c]ECKENFELDER INC., 1989. "Supplemental Hydrogeologic Assessment, RMI Extrusion Plant, Ashtabula, Ohio".

Therefore, the shallow water-bearing zone in the glacial till deposits and the bedrock water-bearing zone can be subdivided into two groundwater units. The units are separated by a "Type 3" boundary or one that is characterized by permanent fresh water-saline water contacts. Because only the uppermost unit (i.e., the glacial till zone) would be potentially impacted by activities at the RMI site, a classification decision will be made for this unit only, per USEPA guidance (USEPA, 1986a).

4.2.4.2 **Preliminary Surveys**. A well survey was performed for the CRA. Figure 4-20 provides the locations of the four wells that are located within the CRA. All of these wells withdraw water from the shale bedrock. There are no domestic or municipal wells screened in the shallow, glacial till groundwater unit (Personal Communication, 1989, Jim Raab, Ohio Department of Natural Resources). Therefore, no groundwater in the CRA is withdrawn from the shallow groundwater unit and used as a source of drinking water.

The presence of habitats for listed or proposed Federal endangered or threatened species, as well as Federal lands managed for ecological values, were surveyed for the CRA through the Natural Heritage Program database. The results of the survey indicate that no such species or managed lands are present in the CRA. There are also no existing or proposed State nature preserves or scenic rivers in the CRA. However, Walnut Beach Park was noted as an ecologically significant site because of the presence of several State threatened plant species (Ohio Department of Natural Resources, March 1989). However, this area, located across the Ashtabula River from the plant site, (shown on Figure 4-20), is not a candidate for groundwater discharge originating from the RMI Sodium Plant and is not affected by Sodium Plant activities.

A survey for public water supply reservoirs within watersheds designated for water quality protection was also conducted for the CRA. Although Lake Erie is located within the CRA and is used for public water supply, a watershed protection area for Lake Erie has not been designated (Personal Communication, 1989, Dan Halterman, Ohio Division of Water; Personal Communication, 1989, Dan Kush, Ohio Division of Soil and Water Conservation).

4.2.4.3 **Class III Criteria.** Once the preliminary process described above has been completed, the following conditions must also be met to satisfy the Class III criteria (USEPA, 1986a):

- There would be insufficient yield at any depth within the groundwater unit to provide for the needs of any averaged-size household (yield must be greater than 150 gpd).

- There are no wells or springs in the CRA used as a source of drinking water regardless of well yield.

The CRA has been described as a poor area for developing even minimal domestic supplies (Hartzell, 1978). Because there are no wells installed in the CRA in the shallow groundwater unit, well yield data were not available from State or local sources of information. Therefore, an estimated well yield was calculated using data from monitoring wells installed at the RMI Sodium and RMI Extrusion plant sites.

As discussed in Section 4.2.2, hydraulic conductivity data are available only for monitoring wells installed in the upper, weathered till. Therefore, hydraulic conductivity data for the lower, unweathered till zone are not available for the RMI Sodium Plant. However, a number of wells at the nearby RMI Extrusion Plant (approximately ½ mile away) are screened in the lower, unweathered till zone. This till has been observed to be very similar to the till at the Sodium Plant. Hydraulic conductivity data for these wells will be used to represent the lower, unweathered till zone at the Sodium Plant.

Using these hydraulic conductivity data and the following Equation 4.3 (Walton, 1979), an estimated well yield was calculated for each of the till zones:

$$\frac{Q}{s} = \frac{T}{264 \log \dfrac{Tt}{(2{,}693 rRw^{2}S)} - 65.5} \qquad (4.3)$$

Where:

Q/s = specific capacity in gpm/ft

Q = Discharge or yield in gpm

s = drawdown in ft

T = coefficient of transmissibility in gpd/ft

S = storativity (dimensionless)

r_w = nominal radius of well in ft

t = time after pumping started in minutes

Calculation of yield in the upper, weathered till zone was conducted using the following assumptions:

k = hydraulic conductivity = 2.0×10^{-5} cm/sec

b = saturated thickness = 8 ft

.s = drawdown = 8 ft

T = coefficient of transmissibility = $(k)(b)$ = 3.4 gpd/ft

S = 0.3

r_w = 0.5 ft

t = time after pumping started = 1 week or 1×10^4 min

The hydraulic conductivity value of 2.0×10^{-5} cm/sec was used as it is the geometric mean value calculated for the till wells at the Sodium Plant (see Table 4-1) and thus represents the weathered portion of the glacial till.

Saturated thickness was obtained by using the minimum depth to water measurements obtained from wells 3S through 10S shown in Table 4-2 (wells 1S and 2S were not used as water levels in these wells may be affected by the presence of a DNAPL, as discussed in Section 6.6.2). The average minimum depth to water was calculated to be approximately 3 ft. This number was then subtracted from the average weathered till/fill thickness at the site of 11 ft (see Section 4.2.1) to obtain an average saturated thickness of 8 ft. By using the average minimum depths to water surface, a maximum average saturated thickness is obtained and produces a conservative number (i.e., higher yield).

Drawdown (s) was assumed to be 100 percent of the saturated thickness in the unweathered till zone or 8 ft. A transmissivity (T) of 3.4 gpd/ft can be calculated using the hydraulic conductivity and the saturated thickness values assumed.

A typical value of storativity (S) can be assumed to be 0.3 (Freeze and Cherry, 1979). A well radius (r_w) of 0.5 ft was assumed as a typical radius for a domestic well (Walton, 1979). Because the equation was applied to a domestic well which would be in relatively continuous use, a relatively long time period (t) of one week was assumed.

Using Equation 4.3, the specific capacity for the weathered till zone is calculated to be 0.006 gpm/ft. Applying this value over the amount of drawdown in the upper till unit at 8 ft, yield, or Q, is calculated to be 75 gpd (see Appendix 5 for well yield calculation work sheets).

Calculation of yield in the lower, unweathered till zone was calculated using these assumptions:

k	=	8.1×10^{-8} cm/sec
b	=	40 ft
s	=	32 ft
T	=	(k)(b) = 0.07 gpd/ft
S	=	0.3
r_w	=	0.5 ft
t	=	1 week = 1×10^4 minutes

The hydraulic conductivity of 8.1×10^{-8} cm/sec was used in this case as it is the mean hydraulic conductivity value calculated for wells screened in the unweathered till at the RMI Extrusion Plant (see Table 4-1). The average thickness of the unweathered till at the Sodium Plant is 40 ft and is assumed to be the saturated thickness (b) for the unweathered till zone. Drawdown (s) was assumed to be 80 percent of the saturated thickness or 32 ft. A transmissivity of 0.07 gpd/ft can be calculated using the hydraulic conductivity and the saturated thickness values assumed. Storativity (S), well radius (r_w), and time (t) were again assumed to be 0.3, 0.5 ft, and one week, respectively.

Using Equation 4.3, the specific capacity for the unweathered till zone is calculated to be 0.0009 gpm/ft. Applying this value over the amount of drawdown in the lower till unit at 32 ft, yield, or Q, is calculated to be 42 gpd (see Appendix 5 for well yield calculation work sheets).

By adding the yield of the two till zones, a total yield of 117 gpd is calculated for the entire glacial till unit. Therefore, well yield in the glacial till meets the first Class III criterion of well yield being less than 150 gpd.

There are no springs used as a source of drinking water in the CRA (Personal Communication, 1989, Raymond Saporito, Ashtabula Co. Health Department). As discussed above, no groundwater in the CRA is withdrawn from the uppermost groundwater unit and used as a source of drinking water. Therefore, the second Class III criteria is met in that there are no wells used for a source of drinking water that withdraw water from the shallow groundwater unit and there are no springs used as a source of drinking water.

Once the groundwater unit has met the Class III criteria, it must be further categorized as Subclass IIIA or Subclass IIIB. The groundwater unit in question may be categorized as Subclass IIIA on the basis of insufficient yield (see Figure 4-19).

In summary, the CRA was delineated as a two mile radius around the RMI Sodium Plant facility boundaries. The CRA was then subdivided into two groundwater units on the basis of fresh water-saline water contacts (a Type 3 boundary). Because only the uppermost groundwater unit (i.e., the glacial till zone) is potentially impacted by activities at the facility, a classification decision was made for this unit only.

Preliminary surveys were conducted and the results of the surveys indicated the following: four wells are located in the CRA, none of which withdraw water from the uppermost groundwater unit; there are no Federal endangered or threatened species or critical habitats in the CRA and there are no ecologically vital areas in the CRA that are located in areas that would receive discharge of groundwater affected by RMI Sodium Plant activities; and, there are no watershed protection areas for public water supply reservoirs which overlap the CRA.

Based on data from monitoring wells screened in the weathered till at the RMI Sodium Plant and from monitoring wells screened in the unweathered till at the RMI Extrusion Plant, it was determined that the wells installed in the glacial till would not produce a sufficient yield to meet 150 gpd criterion for the needs of an averaged-size household. It was also determined that no springs or wells installed in the glacial till in the CRA are used as a source of water supply. Based on these criteria and the results of the preliminary surveys, it is proposed that the uppermost groundwater unit be classified as Class IIIA groundwater.

4.3 AREA SOIL PATTERNS

Soils in the immediate vicinity of the RMI Sodium Plant have been developed for various purposes and the original soils have been greatly altered. In areas surrounding the plant, a number of soil map units are present. The following is a discussion of the major map units.

The soils in the plant vicinity are generally characterized by poorly drained, nearly level to gently sloping silt loams of the Conneaut and Platea soil series. These soils were formed in the silt loam glacial till of Wisconsin age. They are characterized by very low permeability and high seasonal water tables. Associated with these soils is the Red Hook silt loam which is formed in poorly sorted glacial outwash derived mainly from shale and sandstone.

This soil type also has a seasonal high water table and slow vertical permeability, but layers of coarse materials can transmit water horizontally at a rapid rate (U.S. Soil Conservation Service, 1973).

Along edges of terraces or where the lacustrine parts of the lake plain have been down cut, "steep land" soils are present. They typically form a narrow and winding pattern and commonly have slopes of between 18 to 50 percent. They are predominantly composed of silts and clays of lacustrine origin (U.S. Soil Conservation Service, 1973).

Along the floodplain of Fields Brook in the vicinity of the plant site, the Holly silt loams are present. These soils are level, poorly drained soils formed in loamy alluvium washed from soils that formed primarily in loamy glacial till. They typically have a moderately slow permeability. Associated with the Holly silt loams is the Braceville loam soil series. These soils are typically deep, moderately well drained and nearly level to sloping. The soils are formed in loamy material and in underlying stratified sand and gravel derived largely from sandstone, shale, and some limestone. A fragipan is typically present between depths of 21 to 34 in. Because of this fragipan, these soils have a moderately slow permeability.

In association with the Holly and Braceville series is a minor presence of the Atherton silt loam. It is characterized by a high water table and by poorly drained deposits overlying deposits of sandy and gravelly material. The soils are nearly level with slow permeability in the upper portions and higher permeability in the coarse textured material. The surface layer is suspectible to crusting.

Along unaltered portions of the Ashtabula River, the Lobdell silt loam is present. This soil type is nearly level, deep, moderately well drained and is formed in sediments that are dominantly silt loam or loam. These soils are subject to flooding and are characterized by a high seasonal water table and moderate permeability.

East of the developed soils occupying the Elkem Metals property, the Swanton fine sandy loam with silty subsoil variant is the major soil type along with the Conneaut and Platea soils. The Swanton soils are deep, poorly drained, and nearly level with a seasonal high water table. The upper 18 to 40 in. has more sand than the lower portion of the soil column and consequently permeability of the upper layers is rapid while the lower portion has a slow permeability.

A summary of the characteristics of the soil types discussed above is provided in Table 4-6. In Figure 4-21, the soil patterns in the vicinity of the Sodium Plant are shown.

4.4 SURFACE WATER AND SEDIMENT

4.4.1 Regional Surface Water

As shown on Figure 4-5, the predominant drainage system in the vicinity of the RMI site consists of Fields Brook and its tributaries which flow into the Ashtabula River and then into Lake Erie.

Fields Brook, which drains the RMI site area, is also the major drainage system for the eastern part of the City of Ashtabula. It has a overall length of approximately 5.5 miles, with a main channel length of 3.5 miles. It discharges into the Ashtabula River about 8,000 ft upstream from Lake Erie (USEPA, 1985).

Five tributary streams are associated with Fields Brook. Among them is the DS Tributary which flows southwesterly through the RMI site and then westerly between RMI Sodium and the Detrex facility and proceeds southwesterly to flow into Fields Brook (USEPA, 1985).

The characteristics of Fields Brook vary along its length. Two sections of the Brook have been channelized with typical sections being 3 to 4 ft wide.

TABLE 4-6

CHARACTERISTICS OF SOILS IN VICINITY OF THE RMI SODIUM PLANT
ASHTABULA, OHIO

Soil Series and Map Symbol	Depth From Surface[a] (inches)	Unified Soil Classification	USDA Texture	Depth to Seasonally High Water Table (feet)	Depth to Bedrock (feet)	Range In Permeability (inches/hour)	Remarks
Atherton: At	0-19	ML, ML-CL	Silt loam	0-0.5	5	0.63-2.0	Surface layer susceptible to crusting
	19-32	ML, CL	Gravelly silt loam			0.06-0.2	
	32-50	GM, GW-GM	Loamy gravel			6.3	
Braceville: BrB, BrC2	0-10	ML	Loam	1.5-3	6	0.63-2.0	Fragipan present at depth from 21 to 34 in.
	10-29	ML, ML-CL	Silt loam			0.63-2.0	
	29-34	SM	Loamy sand			0.2-0.63	
	34-60	GM, SM	Sand and gravel			6.3-12.0+	
Conneaut: Ct	0-27	ML, ML-CL	Silt loam	0-0.5	6	0.2-0.63	Dominant nearly level soil of lake plain
	27-70	CL, ML-CL	Silt loam			0.06-0.2	
Holly: Hm	0-10	ML, CL	Silt loam	0-0.5	6	0.63-2.0	Occupies floodplain of most smaller streams in the county
	10-27	ML-CL, CL	Silty clay loam			0.2-0.63	
	27-50	ML	Loam			0.2-0.63	
Lobdell: Lb	0-14	ML, CL	Silt loam	1.5-3	6	0.63-2.0	Occupies floodplains of major streams in the county
	14-50	ML, CL	Silt loam			0.63-2.0	
Platea: PsB, PsC, PsC2	0-13	ML	Silt loam	0.5-1.5	6	0.2-2.0	Dense fragipan in lower portion of subsoil
	13-18	ML, CL	Silty clay loam			0.2-0.63	
	18-60	CL, ML-CL	Silt loam			0.06	
Red Hook: RhB	0-15	ML, ML-CL	Silt loam	0.5-1.5	6	0.63-2.0	
	15-36	ML	Loam			0.06-0.2	
	36-54	SM	Gravelly sandy loam			2.0-6.3+	
Swanton: Sw	0-11	SM	Fine sandy loam	0-0.5	6	0.63-2.0	
	11-27	SM	Fine sandy loam			0.63-2.0	
	27-70	CL, ML-CL	Silt loam			0.06	

[a]Typical profile.

SOURCE: U.S. Soil Conservation Service, (1973), "Soil Survey of Ashtabula County, Ohio".

In one section, the original streambed has been removed and replaced with a gravelly substrate and the stream cross section has been replaced with a shallow trapezoid section for about 200 ft. Another section flows through a 500-ft long culvert under an industrial plant parking lot. Other sections have retained a more natural state and may be braided, pass through ravines, or flow over bedrock (USEPA, 1985).

The section of Fields Brook flowing approximately 1,500 ft south of the RMI Sodium Plant site is braided and characterized by several intertwined, U-shaped channels about 10 to 15 ft wide that are downcutting through the soil. Sediment beds are present on the convex sides of bends. The banks are heavily overgrown with brush, bushes, and small trees. Downstream of the braided section, beginning at the confluence of the DS tributary and the Brook, Fields Brook is about 20 to 25 ft wide and in a more natural state. Fewer bends are present and sediment appears to be uniformly distributed. The stream banks are covered with dense brush and trees (USEPA, 1985).

Designated uses for Fields Brook include: limited warmwater habitat, agricultural and industrial supply, and primary contract recreation (Personal Communication, 1989, Bob Heitzman, Ohio EPA). Water quality standards based on use designations for Fields Brook are summarized in Appendix 6.

Several industries have wastewater discharges into Fields Brook. In addition, runoff and/or seepage from these industries may have adversely affected the quality of Fields Brook and associated sediments. Consequently, Fields Brook has been designated as a USEPA Superfund Site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). A Remedial Investigation was conducted in 1983 and 1984 by a USEPA Remedial Planning/Field Investigation Team. During this investigation, water quality samples were collected from one sampling station on the DS tributary (station number 024) and from the outfalls of RMI Sodium, Diamond Shamrock, and Detrex. The results of the sampling effort is summarized in Table 4-7. Sample locations are shown in Figure 4-22.

TABLE 4-7

WATER QUALITY SAMPLING RESULTS
FIELDS BROOK REMEDIAL INVESTIGATION
DS TRIBUTARY AND PLANT OUTFALLS

Parameter (expressed in ppb)	Station No. 024	RMI Sodium Outfall	Diamond Shamrock Outfall	Detrex Outfall
Volatile Organics				
Chlorobenzene	ND	ND	BMDL	ND
Carbon tetrachloride	ND	ND	140	ND
1,2-Dichloroethane	ND	ND	BMDL	ND
Chloroform	ND	ND	55	ND
Acetone	ND	ND	5,500	ND
1,1,2-Trichloroethane	50	ND	BMDL	22
1,1,2,2-Tetrachloroethane	1,900	ND	ND	160
1,2-trans-Dichloroethene	150	ND	ND	12
Methylene chloride	50	ND	22/8.3[a]	5.6
Tetrachloroethene	230	ND	ND	51
Trichloroethene	1,300	ND	9.6	210
Base Neutral Compounds				
N-Nitrosodiphenylamine	BMDL	ND	ND	ND
Diethyl phthalate	BMDL	ND	ND	ND
Benzo(b)fluoranthene	ND	BMDL	ND	ND
Benzo(k)fluoranthene	ND	BMDL	ND	ND
Chrysene	ND	BMDL	ND	ND
Inorganics				
Aluminum	BMDL[b]	BMDL[b]	BMDL/BMDL[a,b]	9,700[b]
Chromium	BMDL	BMDL	BMDL/BMDL[a]	74
Barium	650	600	BMDL/BMDL[a]	300
Beryllium	BMDL[c]	BMDL[c]	BMDL/BMDL[a,c]	BMDL[c]
Cobalt	BMDL	BMDL	BMDL/BMDL[a]	BMDL
Copper	BMDL	BMDL	BMDL/BMDL[a]	230
Iron	500	180	470/680[a]	2,500
Nickel	BMDL	BMDL	BMDL/BMDL[a]	BMDL
Manganese	32	49	69/43[a]	4,100
Zinc	BMDL[b]	23[b]	16/10[a,b]	300[b]
Boron	200[b]	130[b]	210/590[a,b]	630[b]
Vanadium	BMDL	BMDL	BMDL/BMDL[a]	BMDL
Silver	BMDL	BMDL	BMDL/BMDL[a]	BMDL
Arsenic	No data[c,d]	No data[c,d]	No data[c,d]	No data[c,d]
Antimony	BMDL	BMDL	BMDL/BMDL[a]	BMDL
Selenium	No data[d]	No data[d]	No data[d]	No data[d]
Thallium	BMDL	BMDL	BMDL/BMDL[a]	BMDL
Mercury	0.7[b,e]	0.4[b,e]	0.4/1[a,b,e]	0.9[b,e]
Tin	BMDL[d]	BMDL[d]	BMDL/20[a,d]	BMDL[d]
Cadmium	6.2[e]	BMDL	BMDL/BMDL[a]	BMDL
Lead	BMDL	BMDL	BMDL/6.7[a,e]	BMDL
Cyanide	BMDL	BMDL	BMDL/BMDL[a]	BMDL

[a]Duplicate

[b]QA data indicate duplicate analyses were not within the suggested limit.

[c]QA review cautions using this data because continuing calibrations were not within contract-required limits.

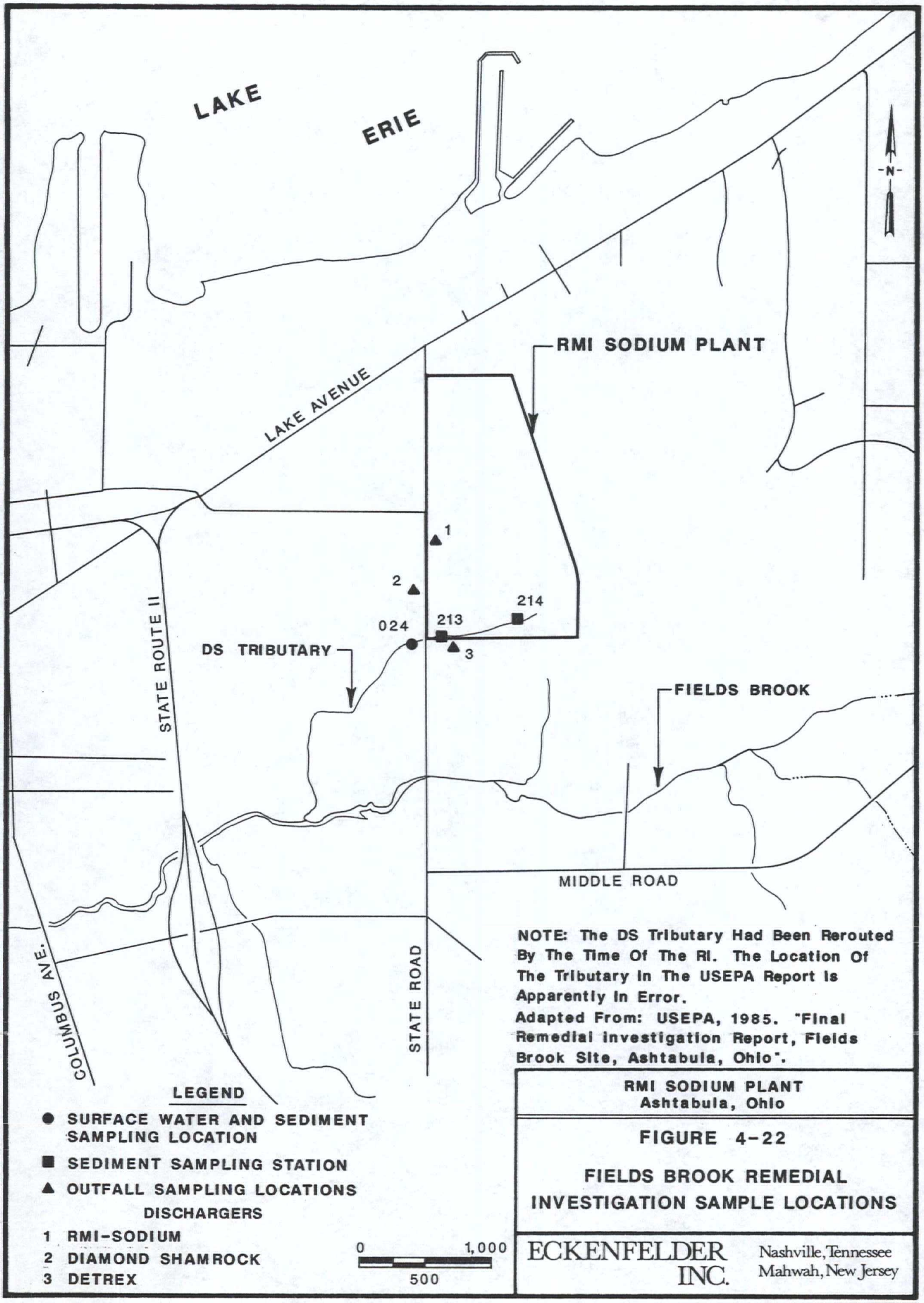
[d]QA data indicate these results are unuseable because of insufficient spike recoveries.

[e]QA review indicate data is semi-quantitative.

ND = No Detected

BMDL = Below Minimum Detection Limit

Source: USEPA, 1985. "Remedial Investigation Report, Fields Brook Site, Ashtabula, Ohio".



NOTE: The DS Tributary Had Been Rerouted By The Time Of The RI. The Location Of The Tributary In The USEPA Report Is Apparently In Error.
Adapted From: USEPA, 1985. "Final Remedial Investigation Report, Fields Brook Site, Ashtabula, Ohio".

LEGEND

- ● SURFACE WATER AND SEDIMENT SAMPLING LOCATION
- ■ SEDIMENT SAMPLING STATION
- ▲ OUTFALL SAMPLING LOCATIONS

DISCHARGERS

1 RMI-SODIUM
2 DIAMOND SHAMROCK
3 DETREX

RMI SODIUM PLANT
Ashtabula, Ohio

FIGURE 4-22

FIELDS BROOK REMEDIAL INVESTIGATION SAMPLE LOCATIONS

ECKENFELDER INC.
Nashville, Tennessee
Mahwah, New Jersey

As shown in Table 4-7, several volatile compounds were detected in samples collected at station number 024 located on the DS tributary downstream of the outfalls sampled. None of these organics were detected in the RMI outfall samples.

Of the inorganics tested, barium, iron, manganese and boron were detected in samples collected at station number 024. In addition, zinc was detected in each of the outfall samples although it was not detected in the DS tributary sample.

The Ashtabula River is formed by the confluence of the West Branch Ashtabula River and the East Branch Ashtabula River in Monroe Township. The River then flows northwesterly and empties in Lake Erie at Ashtabula. Including the West Branch, the Ashtabula River is approximately 40 miles long with a total drainage area of 137 sq mile (USEPA, 1985).

Approximately 80 percent of the Ashtabula River basin is used for farming and woodlands; most industrial development is in the Fields Brook drainage basin and in the area surrounding the City of Ashtabula (USEPA, 1985). The designated uses for the river are warm water habitat, agricultural and industrial supply, and primary contact recreation (Ohio EPA, 1987). Water quality standards based on use designations for the Ashtabula River are contained in Appendix 6.

Where the Ashtabula River discharges into Lake Erie, use designations are the same as those listed for the Ashtabula River. The rest of Ohio Lake Erie, outside of excepted areas, is designated as Lake Erie habitat. Uses for the Lake Erie habitat are specified as public, agricultural, and industrial water supply; and bathing waters. The waters are capable of supporting populations of Lake Erie fish and associated vertebrate and invertebrate organisms on an annual basis, and are waters that meet specified criteria (Ohio EPA, 1987).

Lake Erie drains an area of 29,650 sq mile and occupies 9,970 sq mile. It is the main source of water supply in the Ashtabula area, serving approximately 24,500 people.

4.4.2 On Site Surface Water Drainage

On site surface water drainage patterns are depicted on Figure 4-23. The figure indicates that there is a subbasin divide within the main process area of the plant site. Water falling south of the divide will generally be intercepted by ditches which flow to the west and south, ultimately discharging into Fields Brook. Water falling north of the divide will flow off site to the north and, presumably, ultimately into Lake Erie.

Catch basins and surface drains are also shown on Figure 4-23. These basins and drains intercept surface water flow mainly in the process and wastewater treatment pond areas. The plant sewer system terminates in a 36 in. sewer which discharges to a 48 in. storm sewer on State Road. It is permitted by NPDES Permit No. OH31E00012*AD. This storm sewer is used by other industries along State Road and discharges directly into Fields Brook.

4.4.3 Flood Potential

According to the Flood Insurance Rate Map for Ashtabula County (Panel 125), the RMI Sodium Facility is not located within the 100-yr floodplain (FEMA, 1981). Therefore, the chance of flooding at the facility is minimal.

4.4.4 Sediments

The sediments of Fields Brook and its tributaries have been the subject of numerous sampling studies. During the Remedial Investigation conducted by USEPA in 1983 and 1984, sediment samples from the DS tributary were collected and analyzed. Three sample stations were located in the vicinity of the RMI Sodium Plant. According to the Remedial Investigation Report (USEPA, 1985), station number 214 was located at the point where the DS tributary leaves the Sodium Plant property. Downstream of this location were station numbers 213, just upstream of State Road, and 024, just downstream of State Road, (see Figure 4-22). Samples collected from station number 214 had detectable concentrations of volatile organics and base neutral compounds. Included in the base neutral compounds detected are numerous polynuclear aromatic hydrocarbons (PAH's) commonly found in coal (see Table 4-8). In general these compounds were detected only in the top 12 in. of sediment collected; in samples collected from 12 to 20 in., concentrations were below detection levels (with the exception of phenanthrene and pyrene). These compounds were not detected in samples 213 and 024 (downstream from station number 214).

Volatile and base neutral compounds were also detected in samples collected from station numbers 213 and 024. In addition, the pesticide heptachlor was detected at station 024.

The results of analyses for inorganic parameters are shown in Table 4-9. Of the metals tested, silver, selenium, and thallium were not detected at any of the three sample locations; antimony was detected only at station number 213. The highest concentrations of the parameters tested were found in samples collected from station number 214 with the exception of aluminum, chromium, iron, vanadium, and antimony. In the majority of the samples collected from station number 214, the greatest concentrations of the inorganics occurred at depths below 6 in. Zinc, tin, and cadmium were the exceptions to this trend.

4.5 CLIMATOLOGICAL INFORMATION

The climate in the Ashtabula area is classified as continental, but it is moderated somewhat due to the influence of Lake Erie. West through northerly winds from the lake cause a lowering of daily high temperatures in the summer and a rise in temperatures and increased cloudiness during the winter.

Table 4-10 provides a summary of the climatological data available from the Ashtabula, Ohio station for the years 1978 through 1987. During this period of record, temperatures recorded ranged from a low of $-16^{o}F$ to a high of $95^{o}F$.

Average annual rainfall ranged from 28.6 to 46.6 in. during this time period. Total inches of snowfall per year ranged from 46.5 to 56.0 in. for the years in which there was a complete record (i.e., no missing data).

TABLE 4-8

DS TRIBUTARY ORGANIC SEDIMENT DATA
FIELDS BROOK REMEDIAL INVESTIGATION

Parameter (expressed in g/kg-dry wt.)	Sample Station No. 024 (0-6 in.)[a]	213 (0-6 in.)	213 (6-12 in.)	214 (0-6 in.)	214 (6-12 in.)	214 (12-20 in.)
Volatile Compounds						
1,1,2,2-Tetrachloroethane	BMDL[b]/9,326/112,952	22	320	ND[c]	55,000	180,000
Chloroform	BMDL/BMDL/BMDL	14	ND	ND	ND	ND
1,1-Dichloroethene	ND	BMDL	2,100	ND	ND	ND
1,2-trans-Dichloroethene	ND	4,000	ND	42,000	32,000	16,000
Methylene Chloride	ND/7,891/8,283	ND	ND	ND	ND	ND
Tetrachloroethene	BMDL/15,782/57,229	790	120	14,000	160,000	110,000
Trichloroethene	ND/BMDL/70,783	340	76	15,000	160,000	160,000
Vinyl Chloride	ND	31	ND	ND	ND	ND
Acetone	10,695/10,043/ND	86	ND	ND	ND	ND
2-Butanone	29,947/30,129/36,145	ND	ND	ND	BMDL	ND
Pesticides						
Heptachlor	ND/7,934/22,741[d]	ND	ND	ND	ND	ND
Acid Compounds						
Benzoic Acid	ND	BMDL	ND	ND	ND	ND
Base-Neutral Compounds						
Acenaphthene	ND	ND	ND	ND	BMDL	ND
1,2,4-Trichlorobenzene	ND	ND	ND	BMDL	2,800[e]	240[e]
Hexachlorobenzene	BMDL/243,902/225,904	BMDL	ND	730,000[e]	810,000[e]	35,000[e]
Hexachloroethane	ND/2,400/33,133	ND	ND	ND	49,000[e]	ND
1,2-Dichlorobenzene	ND	BMDL	BMDL	BMDL	2,600[e]	290[e]
Fluoranthene	ND	BMDL	ND	7,300[e]	7,000[e]	530[e]
Hexachlorobutadiene	4,376/BMDL/97,892	250[e]	ND	26,000[e]	140,000[e]	18,000[e]
Naphthalene	ND	ND	ND	BMDL	ND	BMDL
Bis(2-ethylhexyl)phthalate	ND	ND	ND	1,200[e]	1,300[e]	ND
Diethyl phthalate	ND	ND	ND	BMDL	ND	BMDL
Benzo(a)anthracene	ND	ND	ND	3,700[e]	3,800[e]	ND
Benzo(a)pyrene	ND	ND	ND	5,700[e]	5,900[e]	ND
Benzo(b)fluoranthene	ND	ND	ND	3,400[e]	3,300[e]	ND
Benzo(k)fluoranthene	ND	ND	ND	2,900[e]	3,100[e]	BMDL
Chrysene	ND	ND	ND	3,400[e]	3,600[e]	ND
Anthracene	ND	ND	ND	1,100[e]	970[e]	ND
Benzo(ghi)perylene	ND	ND	ND	3,900[e]	3,100[e]	ND
Fluorene	ND	ND	ND	BMDL	BMDL	ND
Phenanthrene	ND	BMDL	ND	6,100[e]	6,000[e]	540[e]
Pyrene	ND	BMDL	ND	6,000[e]	5,400[e]	460[e]
Dibenzofuran	ND	ND	ND	BMDL	BMDL	ND

[a]Samples collected from station number 024 were taken in triplicate

[b]BMDL = Below Minimum Detection Limit

[c]ND = Not Detected

[d]Laboratory indicates that compound was detected below GC/MS detection limits.

[e]QA review indicates data is semi-quantitative.

Source: USEPA, 1985. "Remedial Investigation Report, Fields Brook Site, Ashtabula, Ohio".

TABLE 4-9

DS TRIBUTARY INORGANIC SEDIMENT DATA
FIELDS BROOK REMEDIAL INVESTIGATION

Parameter (expressed in mg/kg--dry wt.)	Station Number 024 (0-6 in.)[a]	213 (0-6 in.)	213 (6-12 in.)	214 (0-6 in.)	214 (6-12 in.)	214 (12-20 in.)
Aluminum	11,631/8,895/7,756	17,874	14,060	10,943	14,404	16,531
Chromium	17.4/18.7/61.7	22.8	17.7	33.7	36.9	13.1
Barium	41.4/2,654/1,244	106.5	113.1	2,862	4,139	312.2
Beryllium	1.07/1.15/0.75	1.46	1.29	1.85	1.82	2.45
Cobalt	20.1/BMDL[b]/6.0	17.4	23.9	15.7	18.9	25.5
Copper	17.4/41.6/34.6	15.9	11.1	80.0	93.0	33.7
Iron	62,433/36,585/33,886	29,353	20,000	32,492	45,861	42,347
Nickel	33.4/107.0/34.6	22.3	27.5	96	122.5	42.9
Manganese	463/527/855	219	164	400	487	3,673
Zinc	119/164/139	113.6	100.8	314	229.6	257.1
Boron	BMDL/7.2/BMDL	NA[c]	NA	NA	NA	NA
Vanadium	26.7/17.2/15.1	37.4	26.5	20.2	23.2	BMDL
Silver	BMDL/BMDL/BMDL	BMDL	BMDL	BMDL	BMDL	BMDL
Arsenic	9.0/8.8/BMDL	8.8	5.7	16.0	21.5	20.4
Antimony	BMDL/BMDL/BMDL	2.9	BMDL	BMDL	BMDL	BMDL
Selenium	BMDL/BMDL/BMDL	BMDL	BMDL	BMDL	BMDL	BMDL
Thallium	BMDL/BMDL/BMDL	BMDL	BMDL	BMDL	BMDL	BMDL
Mercury	NA	0.4	BMDL	1.0	1.5	0.3
Tin	1.9/2.3/2.7	BMDL	BMDL	4.2	4.1	BMDL
Cadmium	0.80/3.01/1.36	0.5	0.5	20.2	1.5	12.9
Lead	NA	7.6	6.6	123.9	126.3	11.6
Cyanide	NA	BMDL	BMDL	BMDL	0.41	0.87

[a]Samples collected from station number 024 were taken in triplicate.

[b]BMDL = Below Minimum Detection Limit.

[c]NA = Sample not analyzed or value not reported by laboratory.

Source: USEPA, 1985. "Remedial Investigation Report, Fields Brook Site, Ashtabula, Ohio".

TABLE 4-10

SUMMARY OF CLIMATOLOGICAL DATA
ASHTABULA, OHIO

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Temperature (^{o}F)										
Maximum	95	89	94	93	90[a]	94	91	92	91[a]	90[a]
Minimum	-15	-5[a]	-8	-6	-16	-8	-13[a]	-4[a]	--[b]	-8
Mean	46.6	47.6[a]	47.6[a]	48.4[a]	46.4[a]	49.8	49.2[a]	54.1[a]	--[b]	48.5
Total Rainfall (in.)	28.59	42.25	43.41	46.57	36.45	42.69	33.84[a]	37.65[a]	--[b]	36.09[a]
Snow and Sleet (in.)										
Total Fall	56.0	48.5	33.0[a]	68.7	52.0[a]	46.5	56.5[a]	13.9[a]	--[b]	40.8[a]
Greatest Depth	24	10	7	15	14	10	21[a]	5[a]	--[b]	5[a]

[a]Some data missing.
[b]Insufficient data.

Source: NOAA, 1978-1987. "Annual Climatological Summaries", Station No. 33026403, Ashtabula, Ohio.

Wind data were available for Erie, Pennsylvania for the years 1951 to 1980. These data are summarized in Table 4-11. The mean annual wind speed during this time was 11.2 mph with the highest mean wind speed (13.5 mph) occurring in December. The prevailing wind direction was from the southern quadrant throughout the year, with the exception of March when it was from the north-northeast.

Table 4-11 indicates that peak winds occurred up to 61 mph during the period of record. Peak gust wind direction varies from the west, south, southwest and northwest.

The closest evaporation station to RMI site is in Wooster, Ohio, approximately 90 miles southwest of Ashtabula. Because Wooster is inland rather than along Lake Erie, climatological conditions are likely to be different from those in Ashtabula (Personal Communication NOAA, 1989). Therefore, evaporation data are not available for the RMI site or surrounding areas.

A summary of projected storm events for the Ashtabula area is tabulated in Table 4-12. Rainfall measuring 0.9 in. is projected to occur during a 1 yr, 1 hr storm event; 4.6 in. is expected to fall during a 24 hr, 100 yr storm.

4.6 DEMOGRAPHY AND LAND USE

4.6.1 Demography

The 1980 population of Ashtabula County was 104,215. Of this total, 41 percent, 43,230 people, resided within the six cities and townships that are adjacent to the RMI site: The City of Ashtabula, Ashtabula Township, Kingsville Township, Plymouth Township, Saybrook Township, and Sheffield Township. The City of Ashtabula had the largest population (23,449) of these six government entities (Ashtabula County Planning Commission, 1980).

TABLE 4-11

WIND DATA
1951 THROUGH 1980
ERIE, PENNSYLVANIA

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean Wind													
Speed (mph)	13.3	12.2	12.2	11.6	10.0	9.6	9.1	9.0	10.0	11.2	13.0	13.5	11.2
Prevailing Wind													
Direction	WSW	WSW	NNE	WSW	WSW	S	S	S	S	SSE	SSW	SSW	S
Peak Gust													
Direction	W	S	W	SW	W	W	S	SW	NW	NW	W	W	NW
Speed (mph)	53	46	53	55	46	41	38	53	61	61	49	60	61

Source: NOAA, 1951 through 1980, Climatological Summary, Erie, Pennsylvania.

TABLE 4-12

STORM INTENSITY DATA
ASHTABULA, OHIO[a]

	1-hr Rainfall (inches)	12-hr Rainfall (inches)	24-hr Rainfall (inches)
1-yr Event	0.9	1.6	2.1
10-yr Event	1.7	3.0	3.5
25-yr Event	1.9	3.5	4.0
100-yr Event	2.4	4.2	4.6

[a]Data extrapolated for Ashtabula, Ohio using the "Rainfall Frequency Atlas of the United States", Technical Paper No. 40, U.S. Department of Commerce, 1963.

Population data for Ashtabula County, the City of Ashtabula, and Ashtabula Township are summarized in Table 4-13. These data indicate that a decline in population was observed in the City of Ashtabula and Ashtabula Township between 1970 and 1980 and that a strong decline in the population of Ashtabula County is expected over the next 30 years. The projected population for the county for the years 2000 and 2010 is less than the county population of 1960.

This decline in population has been attributed to a number of industrial plant closings in the early 1980s. At that time, the unemployment rate rose from approximately 7 percent to 16 percent. As of December 1988, the unemployment rate had fallen to 7.8 percent and there have been no major plant closings in the last three years (Personal Communication, 1989, Mike Conway, Ashtabula County Planning Commission).

In 1980, minority populations made up 3.7 percent of the population of Ashtabula County, 9.3 percent of the City of Ashtabula, and 0.8 percent of Ashtabula Township (Ashtabula County Planning Commission, 1980).

Age characteristics for Ashtabula County are shown in Table 4-14. The age group 20 to 64 years old makes up over half of the total population of Ashtabula County. The percentage of people in this age group, as well as those who are 65 years or older, is expected to increase over the next 20 years. The percentage of people younger than 20 years is expected to decline during the same time period.

A summary of income information based on the 1980 census is contained in Table 4-15. Median household income for Ashtabula County was $17,127; median family income was $19,787; and per capita income was $6,523. Income figures for the City of Ashtabula and Ashtabula Township were consistently lower than those for the County in each of these three income categories.

TABLE 4-13

POPULATION DATA

	Ashtabula County	Percent Change	Ashtabula City	Percent Change	Ashtabula Township	Percent Change
1960	93,067	--	24,559	--	7,068	--
1970	98,237	+5.5	24,313	-1.0	7,392	+4.5
1980	104,215	+6.1	23,449	-3.5	7,308	-1.1
1990 (projected)	97,861	-6.1	--	--	--	--
2000 (projected)	90,956	-7.0	--	--	--	--
2010 (projected)	85,401	-6.1	--	--	--	--

Source: Ashtabula County Planning Commission, 1980.

TABLE 4-14

AGE CHARACTERISTICS
ASHTABULA COUNTY, OHIO

Age Groups (years)	1980 Total	1980 Percent of Total Population	1990 (Projected) Total	1990 (Projected) Percent of Total Population	2000 (Projected) Total	2000 (Projected) Percent of Total Population
0-4	7,793	7.5	7,136	7.3	5,620	6.2
5-19	27,440	26.3	23,085	23.6	20,621	22.7
20-64	56,647	54.4	53,680	54.8	50,931	56.0
65+	12,335	11.8	13,960	14.3	13,784	15.1
Total	104,215	--	97,861	--	90,956	--

Source: Ashtabula County Planning Commission, 1980.

TABLE 4-15

INCOME INFORMATION
BASED ON 1980 CENSUS

	Ashtabula County	Ashtabula City	Ashtabula Township
Median Household Income ($)	17,127	14,780	15,264
Median Family Income ($)	19,787	17,949	18,245
Per Capita Income ($)	6,523	--	6,466

Source: Ashtabula County Planning Commission, 1980.